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ABSTRACT The objective of this study was to identify changes in weight that occurred during deployment to Iraq or Kuwait between 2005 and 2008. Data on length and type of deployment among 16,365 male U.S. Navy personnel were combined with weight measurements before and after deployment from the Physical Readiness Information Management System. Weight measurements were available for 10,886 men who did not exceed Navy weight recommendations before deployment. In general, weight increased after deployment and, for those who did not exceed Navy recommendations before deployment, factors associated with weight gain included being enlisted and having a deployment longer than 228 days. Among 1,108 men with 2 deployments, a dwell time shorter than the combined deployed time was a risk factor for weight gain during the second deployment. Future studies should explore the combined effects of long deployments and short dwell times in maintaining the readiness of military personnel.

INTRODUCTION

Deployment to areas of active warfare is associated with various health problems and injuries among military men and women.[1] Although battle and nonbattle injuries are common during deployment, the nature of warfare in Iraq and Kuwait, which includes exposure to blast-related injuries, presents new health challenges to military personnel. For example, mild traumatic brain injuries may lead to psychological stressors or neurological disorders that may not be fully diagnosed until several months after deployment. Because of these findings, many previous studies on deployment-related health issues have focused on psychological stress, anxiety, posttraumatic stress disorder, and suicidal ideation.[1] Although other studies have identified biological changes in serum cholesterol levels and blood pressure during military service,[2] little attention has been devoted to changes in weight that may occur during deployment. Examining weight changes is important because decreases or increases in weight after deployment may be explained by limited access to nutritious foods, limited access to exercise opportunities, or development of psychological conditions such as anxiety or depression.[3] In addition, weight changes may be associated with physical readiness scores or health conditions not yet diagnosed that may have an impact on operational readiness.[4]

Little is known about weight fluctuation associated with single or multiple deployments, especially when considering total length of deployment or dwell time. Psychological changes (increase in the onset or rates of depression, anxiety, and acute stress) have been found to be associated with long deployments or short dwell times between deployments.[5] The purpose of this study was to examine weight changes associated with deployment to Iraq and Kuwait while controlling for length of deployment and dwell time as possible modifiers of these changes.

METHODS

Subjects

Subjects were identified using deployment information obtained from the Defense Manpower Data Center, Monterey, CA. Active duty male U.S. Navy personnel with at least 1 deployment to Iraq or Kuwait between 2005 and 2008 were selected. Deployment start and end dates had to occur between January 1, 2005, and December 31, 2008, and minimum deployment length was set at greater than 1 month. To obtain a more uniform sample, a small percentage of service members ($N = 94$, 0.43%) who were deployed 3 times during the designated period were excluded. We also excluded women because the number of deployed women with complete data was too small for meaningful interpretation. The final sample included 22,034 active duty male Navy personnel. To obtain longitudinal height and weight measurements, these subjects were then matched to Physical Fitness Assessment (PFA) records from 2005 through 2009 found within the Physical Readiness Information Management System (PRIMS). This research was conducted in compliance with all applicable federal regulations governing the protection of human subjects in research (protocol NHRC.2003.0025).

Weight (Outcome) Data

Height and weight measurements were taken semiannually according to the Body Composition Assessment component of the Navy PFA program. Measurements were housed in the

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PRIMS database and available through the Navy Physical Readiness Program Office (OPNAV N135F). All active duty members of the Navy were required to complete a Body Composition Assessment once every 4 to 8 months, except service members who were deployed during the semiannual PFA time period. To incorporate longitudinal measurements of weight, PRIMS data were arranged according to PFA date and compared with deployment start and end dates. For all service members, the most recent weight measurement before the start of the first deployment was considered the pre-deployment 1 weight and the first weight measurement occurring after the end date of the first deployment was considered the post-deployment 1 weight. For service members with 2 deployments between 2005 and 2008, the same methodology was applied to determine pre-deployment 2 and post-deployment 2 weights. Based on these criteria, it was possible for the post-deployment 1 measurement to reflect the same PFA as the pre-deployment 2 measurement. Since all subjects in this study were deployed at least once, many subjects were exempted at 1 time or another from participating in 1 or more PFAs and were therefore missing pre- or post-deployment weight measurements. These exemptions contributed to the exclusion of certain individuals in the final analyses.

Pre- and post-deployment longitudinal weight measurements were used to calculate body mass index (BMI) by dividing each subject's body weight in kilograms by the square of his height in meters. To examine changes in weight from deployment start to finish, the change in BMI and the annual rate of change in BMI were both calculated across deployments. The change in BMI was calculated by subtracting the pre-deployment BMI from the post-deployment BMI. The annual rate of change in BMI was calculated by dividing the change in BMI by the number of days between measurements and multiplying by 365. In previous studies, a 5% increase in BMI has been suggested to hold clinical significance[6]; therefore, a categorical variable indicating a 5% increase, 5% decrease, or less than 5% change from pre- to post-deployment was included in analyses.

To evaluate the effect of weight change on operational readiness, a dichotomous variable indicating if a subject met the Navy recommended weight according to height was created for each time point (OPNAVINST 6110.1H). At the population level, a change in the percentage of subjects exceeding weight recommendations from pre- to post-deployment could indicate a change in overall force readiness level. At the individual level, deployment-related and demographic factors associated with a change in status from pre- to post-deployment could be identified.

Deployment Status

For the purpose of this study, deployments were recognized if a subject received combat zone tax exclusion or hazardous duty/imminent danger pay while deployed to either Iraq or Kuwait. Deployments were required to have started and ended between January 1, 2005, and December 31, 2008. Deployment length was analyzed as continuous and categorical (quartiles) variables. Quartiles were determined based on first deployment length (in days) among our primary population of service members deploying once or twice. These quartiles were then used for all subsequent analyses (Q1: ≤181 days, Q2: 182–207 days, Q3: 208–227 days, and Q4: ≥228 days). Additionally, the effect of exceptionally long deployments was examined by comparing the fourth quartile of deployment length against the lesser 3 quartiles.

Dwell Time

The time between successive deployments, dwell time, was analyzed relative to total length of deployment. The ratio of dwell time to the length of the first and second deployments combined was calculated for subjects with 2 recorded deployments. A dichotomous variable was then created by categorizing the ratio of dwell time to combined deployment length into 2 groups (≤1 and >1).

Demographic Data

Demographic variables used in this study included age and pay grade. Age at the start of deployment 1 or 2 was analyzed as continuous and 2 categorical variables (<20, 20–29, and 30–40 years) and (≤40 and >40 years). Pay grade at the start of deployment 1 or 2 was analyzed as categorical (officer/enlisted).

Statistical Analysis

Descriptive analyses of demographic and deployment-related characteristics were undertaken for service members with available weight and height measurements before and following deployment 1 (n = 16,365). A subsample of this population was then determined by selecting service members who did not exceed the Navy recommended weight for height before deployment 1 (n = 10,866). Analyses were performed on this subsample to evaluate potential risk factors for exceeding the Navy recommended weight following deployment 1. Univariate odds ratios (ORs) with 95% confidence intervals (CIs) were computed and a multivariate logistic regression was performed to generate adjusted ORs with associated 95% CIs.

Demographic and deployment-related characteristics were analyzed for a second population of service members deploying twice, with weight and height measurements before and following both deployment 1 and deployment 2 (n = 1,108). For this population, paired t tests, McNemar's tests, and Bowker's tests for symmetry were conducted to compare demographic and deployment-related characteristics of the first and second deployments. Pre-deployment mean BMI, post-deployment mean BMI, mean change in BMI, and mean annual rate of change in BMI were age adjusted using a generalized linear model (GLM), taking into account individual subject effects. Age-adjusted least squares means (LSMs) were calculated using SAS GLM procedure. LSMs from deployment 1 were compared with those from deployment 2 using an analysis of

covariance test using age as a continuous covariate. LSMs are values predicted by the generalized linear model at the mean age taken across both deployments. One-way analysis of variance and χ^2 tests were performed to test for associations between the dwell time ratio and several indicators of change in BMI. For all analyses, significance was set at the $p < 0.05$ level. All statistical calculations were carried out using SAS, version 9.2 software (SAS Institute Inc., Cary, NC).

RESULTS

Demographic Characteristics

Three analytic samples were selected based on the availability of BMI and weight measures (see Fig. 1). The first sample included 16,365 men who had 1 or 2 deployments with a pre- and post-BMI measure for deployment 1. The second sample included 10,886 men who had a pre- and post-BMI measure for deployment 1 and who did not exceed weight recommendations before their first deployment. The third sample included 1,108 men who had 2 deployments with pre- and post-BMI measures for each deployment.

Group that Deployed Once or Twice

For the population with 1 or 2 deployments (n = 16,365), the mean age at the start of the first deployment was 30 years, with more than half of the population in the 20 to 29 years age group. Over 80% were enlisted, and the mean length of deployment was 214 days. Approximately 60% of the deployments were between 180 and 240 days (Fig. 2). Increases were observed in mean BMI after deployment when evaluating pre-post differences or annualized pre-post differences (Table I). Over the course of their first deployment, approximately 19% of service members experienced a greater than 5% increase in BMI, whereas only 13% experienced a greater than 5% decrease in BMI. Overall, about 35% exceeded weight recommendations after deployment, but among the 10,886 men who met weight recommendations before deployment, 11% exceeded weight recommendations after deployment.

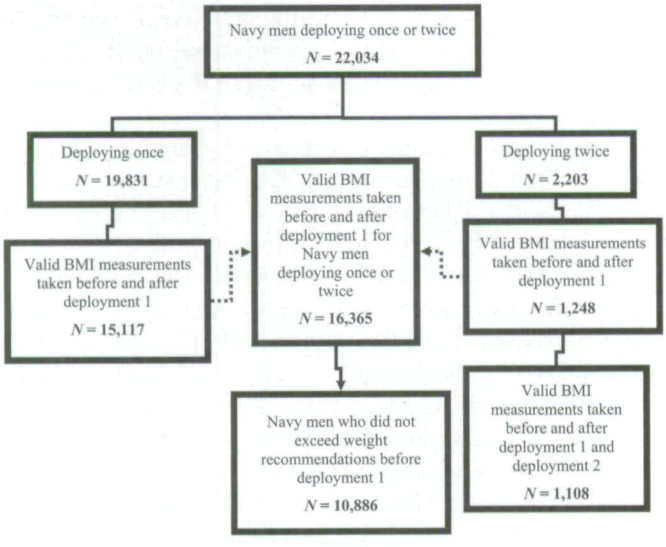

FIGURE 1. Diagram outlining sample sizes used in analyses.

For those deploying once or twice and meeting weight recommendations before deployment 1, the odds of exceeding the Navy weight recommendations after deployment were significantly greater for enlisted service members and those who deployed for 228 days or more (Table II).

A multivariate logistic regression model including grade, length of deployment, and age was used to calculate adjusted ORs (Table III). Results from the multivariate model indicated that enlisted male Navy personnel had 1.5 times the odds of exceeding weight recommendations after deployment compared with male Navy officers. Additionally, male Navy service members who were deployed for 228 days or more had almost 1.3 times the odds of exceeding weight recommendations after deployment when compared with service members deployed for a shorter length of time.

Group that Deployed Twice

For those deploying twice between 2005 and 2008 (n = 1,108), BMI differences were adjusted for age. In the adjusted analysis, the BMI before both deployments was similar, but the adjusted mean BMI following deployment 2 was significantly greater than the adjusted mean BMI following deployment 1. The mean difference in BMI and BMI per year from start to end of deployment remained significantly different between deployment 1 and deployment 2 in the adjusted estimates. In this case, deployment 2 saw an age-adjusted increase in BMI, whereas deployment 1 saw an age-adjusted decrease in BMI (Table IV). Although 18% of men experienced a greater than 5% increase in BMI from pre- to post-deployment 1, over 22% experienced the same increase from pre- to post-deployment 2. Overall, about 29% of those deploying twice exceeded weight recommendations after deployment 1, but a significantly greater percentage (36%) went on to exceed weight recommendations after deployment 2. Among the 785 men who met weight recommendations before deployment 1, 8.5% exceeded weight recommendations after deployment, and among the 755 men who met weight recommendations before deployment 2, approximately 14% exceeded weight recommendations after deployment.

For those deploying twice, the average dwell time was 361.3 days, with a SD of 142.5 days. The ratio of dwell time to the combined length of deployments 1 and 2 was divided into 2 categories (≤1 and >1). For service members with more dwell time than total time deployed (ratio >1), the second deployment mean increases in BMI and BMI per year were 0.13 and 0.12, respectively (Table V). However, for service members with less dwell time than combined deployment time (ratio ≤1), the second deployment mean increases in BMI and BMI per year were significantly higher (0.45 and 0.37, respectively). Having less dwell time than combined deployment time was also found to be associated

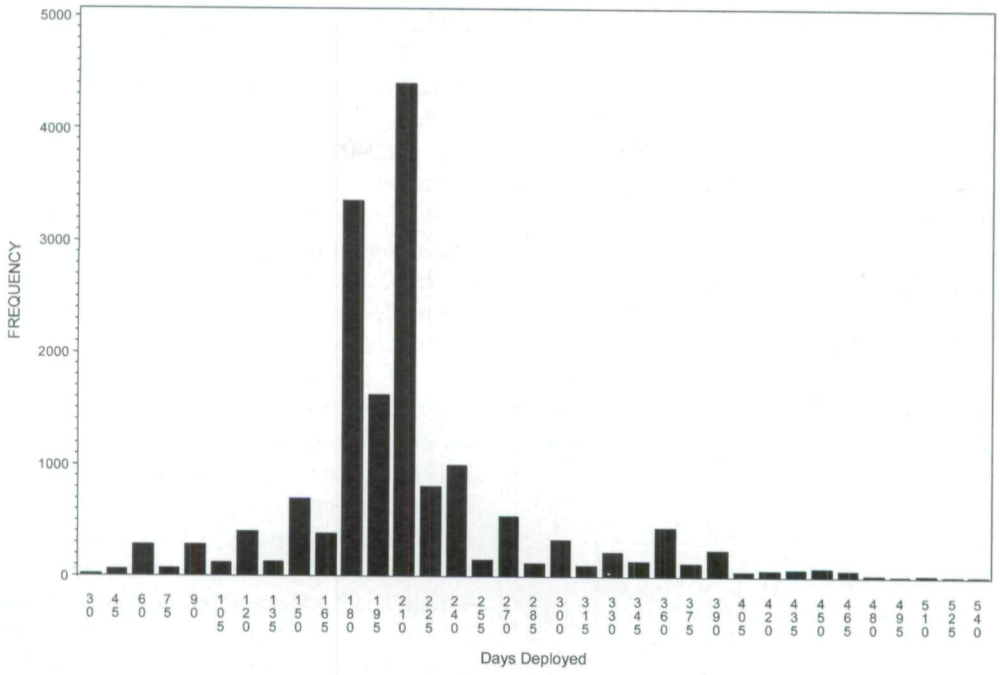

FIGURE 2. Distribution of deployment lengths among Navy men during their first deployment ($N = 16,365$).

TABLE I. Demographic and Deployment Statistics for Navy Men During Deployment 1

	Deployment 1, *n* (%) ($N = 16,365$)
Age (Years)	
<20	366 (2.24)
20–29	8,674 (53.00)
30–39	5,558 (33.96)
≥40	1,767 (10.80)
Mean ± SD	30.03 ± 7.39
Grade	
Officer	2,991 (18.28)
Enlisted	13,374 (81.72)
Length of Deployment (Days)	
<182	3,907 (23.87)
182–207	4,113 (25.13)
208–227	4,228 (25.84)
≥228	4,117 (25.16)
<228	12,248 (74.84)
≥228	4,117 (25.16)
Mean ± SD	214.34 ± 70.57
BMI	
Pre-deployment (Mean)	26.54 ± 3.32
Post-deployment (Mean)	26.67 ± 3.27
Change (Mean)	0.13 ± 1.64
Annual Rate of Change (Mean)	0.06 ± 1.46
>5% Increase	3,062 (18.71)
≤5% Change[a]	11,188 (68.37)
>5% Decrease	2,115 (12.92)
Navy Recommendations	
Exceeded Weight Post-deployment	5,641 (34.47)
Exceeded Weight Post-deployment[b]	1,187 (10.90)

[a]≤5% increase or decrease in BMI. [b]$n = 10,886$ service member who did not exceed weight recommendations before deployment 1.

TABLE II. Univariate ORs for Exceeding the Navy Recommended Weight After Return From Deployment 1

	Deployment 1 ($N = 10,886$)	
	OR	95% CI
Age (Years)		
<20	1.00[a]	
20–29	0.91	0.65–1.28
30–39	0.78	0.55–1.11
≥40	0.71	0.48–1.10
Grade		
Officer	1.00[a]	
Enlisted	1.62	1.36–1.92
Length of Deployment (Days)		
<182	1.00[a]	
182–207	1.01	0.85–1.21
208–227	1.06	0.89–1.26
≥228	1.31	1.11–1.55
<228	1.00[a]	
≥228	1.28	1.12–1.46

Sample did not exceed Navy recommended weight before deployment 1. [a]Reference variable level for ORs.

with a greater than 5% increase in BMI from pre- to post-deployment 2.

DISCUSSION

These data indicated that male Navy service members who deployed twice to Iraq or Kuwait between 2005 and 2008 were likely to gain weight during their second deployment, even after we adjusted for age. Relative to pre-deployment

numbers, the percentage of men exceeding Navy weight recommendations increased upon return from deployment 1 and increased to an even greater extent upon return from deployment 2. These statements support the conclusion that weight gain occurs for many male Navy service members during deployment. By modeling the outcome of exceeding the Navy weight recommendations, we concluded that enlisted service members and service members who were deployed for longer periods of time were at greater odds for weight gain during deployment. Specifically, deployments lasting longer than 228 days were associated with increased BMI and increased BMI per year. Interestingly, the Navy standard length of deployment is set at 210 days. Although we are unclear of the exact role through which deployments prolonged beyond what is standard, expected, or trained for are associated with weight gain, we speculate that this finding may be related to increased stress and recommend that future studies examine this relationship.

When our analyses were confined to subjects with 2 deployments, we observed an increase in mean BMI as a function of time. Studies involving other samples have reported a similar positive correlation between age and BMI. To determine the extent of weight gain independently attributable to deployment, as opposed to increased age, we performed an age adjustment. Age-adjusted means indicated that for an average-aged individual, BMI would be expected to stay the same or decrease across deployment 1, whereas BMI would be expected to increase across deployment 2. The increase in BMI during the second deployment remained after adjusting for age, and we can assume that factors other than age

TABLE III. Adjusted ORs for Outcome of Exceeding the Navy Recommended Weight After Return From Deployment 1

	Deployment 1 (N = 10,886)		
	OR	95% CI	p Value
Grade			
Officer	1.00[a]		
Enlisted	1.56	1.29–1.88	<0.01
Length of Deployment (Days)			
<228	1.00[a]		
≥228	1.31	1.15–1.50	<0.01
Age (Years)			
Continuous	0.99	0.98–1.00	0.16

Sample did not exceed Navy recommended weight before deployment 1.
[a]Reference variable level for ORs.

TABLE IV. Comparison of Demographic and Deployment Statistics for Navy Men During Deployments 1 and 2

	Deployment 1 (N = 1,108)	Deployment 2 (N = 1,108)	p Value
Age (Years)			
<20	55 (4.96)	2 (0.18)	<0.01[a]
20–29	704 (63.54)	688 (62.09)	
30–39	295 (26.62)	343 (30.96)	
≥40	54 (4.87)	75 (6.77)	
Mean ± SD	27.50 ± 6.65	29.01 ± 6.66	<0.01[b]
Grade			
Officer	97 (8.75)	99 (8.94)	0.16[c]
Enlisted	1,011 (91.25)	1,009 (91.06)	
Length of Deployment (Days)			
<182	413 (37.27)	382 (34.48)	<0.01[a]
182–207	273 (24.64)	309 (27.89)	
208–227	303 (27.35)	263 (23.74)	
≥228	119 (10.74)	154 (13.90)	
<228	989 (89.26)	954 (86.10)	0.02[c]
≥228	119 (10.74)	154 (13.90)	
Mean ± SD	190.20 ± 45.50	190.60 ± 56.56	0.85[b]
Age-adjusted BMI			
Pre-deployment (Mean)	26.29 ± 0.09	26.20 ± 0.09	0.64[d]
Post-deployment (Mean)	26.00 ± 0.11	26.91 ± 0.11	<0.01[d]
Change (Mean)	−0.28 ± 0.15	0.71 ± 0.15	<0.01[d]
Annual Rate of Change (Mean)	−0.30 ± 0.15	0.60 ± 0.15	<0.01[d]
>5% Increase	199 (17.96)	250 (22.56)	0.03[a]
≤5% Change	771 (69.58)	751 (67.78)	
>5% Decrease	138 (12.45)	107 (9.66)	
Navy Recommendations			
Exceeded Weight Post-deployment	319 (28.79)	399 (36.01)	<0.01[c]
Exceeded Weight Post-deployment[e]	67 (8.54)	105 (13.91)	

[a]Bowker's test for symmetry. [b]Paired t test. [c]McNemar's test. [d]Analysis of covariance test with age as a continuous covariate. [e]Samples did not exceed Navy recommended weight before deployment. Deployment 1, n = 785; deployment 2, n = 755.

TABLE V. Comparison of BMI Changes During Deployment 2 for 2 Dwell Time Levels Relative to Combined Deployment Length

	N	BMI Change (Mean ± SD)	Annual BMI Rate of Change (Mean ± SD)	>5% Increase in BMI (*n* [%])
Dwell Time Divided by Combined Length of Deployments 1 and 2				
≤1 (Less Dwell Time)	724	0.45 (1.70)	0.37 (1.51)	177 (24.3)
>1 (More Dwell Time)	384	0.13 (1.54)	0.12 (1.46)	73 (19.0)
Total	1,108			
p Value		<0.01[a]	0.01[a]	0.04[b]

[a]One-way analysis of variance. [b]χ^2 test.

contributed to the observed increase in BMI during deployment 2. The findings of a study of National Guard Soldiers found increased depressive and somatic symptoms before their second deployment compared with their first deployment,[7] thus suggesting that stress or anxiety may be present and contribute to weight gain during a second deployment. This is a topic for future research.

Unlike our study, a previous analysis of men from a large cohort of military personnel found moderate weight loss (>3%) among men who deployed without combat exposures compared with men who did not deploy.[8] This study included Army, Navy, Marine Corps, Air Force, and Coast Guard personnel who deployed between 2001–2003 and 2004–2006 and who reported their height and weight on a subsequent survey. The discrepancies in study population, areas of deployment, and methods used to collect weight data (measured vs. self-report) could account for the differences between the 2 studies.

Although there have been several anecdotal reports, this study is the first to document weight increases associated with deployment among men. Although some reports indicate that limited access to healthy foods is responsible for weight increases while deployed, we were not able to determine the specific causes for weight increases from our data. This remains an important area of research for future studies.

One of the strengths of this study was the large study cohort of male Navy personnel with heights and weights measured at several points in time, both before and after deployments. Also, we were able to access deployment data files rather than rely on self-report questionnaires. We used several measures of weight change in this study, including BMI, 5% change in weight, and compliance with Navy recommendations. Although each weight variable measured something different, all were consistent in showing increases associated with deployment.

This study was limited in its assessment of body composition. Although weight measurements were objective and obtained at several points over time, we did not have access to body fat or waist circumference data. The increases we observed in BMI may have been associated with increased muscle mass rather than fat, but our methods did not allow us to separate out this effect.[9] In addition, we were not able to link our data with health-risk appraisal data to determine if other risk factors (e.g., stress, hypertension, and smoking) or comorbidities were present in our population, which could provide more context for weight increases.[10,11]

COMMENTS

This study provides important evidence that weight gain is associated with deployment among male Navy personnel deployed to Iraq or Kuwait between 2005 and 2008. These small, but consistent, weight increases were not due to aging alone, but could also be due to a number of other factors, including access to high-calorie food, lack of exercise opportunities, or stress/anxiety issues that may increase eating behaviors. The finding that a longer dwell time mitigates the weight gain during a second deployment provides important information in the ongoing discussion about optimal dwell time.

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14. ABSTRACT

The study objective was to identify changes in weight that occurred during deployment to Iraq or Kuwait between 2005 and 2008 among male Navy personnel. Data on length and type of deployment was combined with weight measurements from the Physical Readiness Information Management System. Weight measurements pre- and post-deployment were available for 10,886 men who did not exceed weight recommendations predeployment. For men deploying twice, complete weight measurements were available for 1,108 men. In general, increased weight postdeployment and, for those who did not exceed Navy recommendations predeployment, factors associated with weight gain included being enlisted and having a deployment longer than 228 days. Among men with two deployments, a dwell time shorter than the combined deployed time was a risk factor for weight gain during the second deployment. Future studies should explore the combined effects of long deployments and short dwell times on maintaining the readiness of military personnel.

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